significant volumes of TCE leakage from C-400 to the site sewer system, discovered in June 1986. Three fatalities were reported as a result of Plant events: an explosion and fire in C-340 in 1962, electrocution of an electrical maintenance trainee in 1977, and the suffocation of an operator in the collapse of a coal bridge at the steam plant in the 1970s. In addition, in June 1958, a release of HF severely burned a worker who did not return to work.

2.5 Industrial Hygiene and Radiation Protection

Programs for industrial hygiene and radiation protection were in existence from the beginning of Plant operation. Initial Plant training classes included theory and protective actions for working with radioactive and hazardous materials. There were policies and procedures that addressed the radiological protection of workers. PPE was provided and available to workers and in work areas where hazards were deemed greatest and protection was deemed necessary. The amount of formal training given to employees diminished after Plant startup, and much of the knowledge concerning both operations and hazard communication and controls resulted from on-the-job training of new workers by more experienced personnel and by supervisors. Starting in the early 1960s, job hazard analyses (JHAs) were prepared for most work activities and addressed many safety hazards, but not all JHAs adequately addressed radiation protection. Safety committees and regularly scheduled safety meetings, which included radiological subjects, were important elements of the process of hazard communication.

Non-radiation hazards, such as industrial and chemical exposures (primarily HF), were evaluated and addressed throughout the history of the Plant. The evolution of awareness and the application of protection and controls for significant hazards, such as asbestos and polychlorinated biphenyls (PCBs), essentially paralleled that of the regulatory bodies and general industry. Air monitoring of hazardous job sites existed from Plant startup, and health physics personnel monitored air and surface contamination in work areas and recommended additional or modifications to engineering controls or PPE, if deemed necessary. As early as 1952, Plant health physics personnel were aware of the potential hazards of personnel contamination and instituted measures such as monitoring work areas, providing company clothing, and providing frisking devices for workers to monitor themselves before eating or leaving work. However, survey records from the early 1950s indicated that few workers performed self-monitoring.

Identification of asbestos and PCB hazards did not emerge until the 1970s or later. During the fourth quarter of 1973, some of the first air samples for asbestos were taken and sent to Oak Ridge National Laboratory (ORNL) for analysis; however, no formal asbestos program existed until 1987. During this period, OSHA adopted 14 carcinogen standards. In 1975, preparations were under way for a two-year program to provide formal respiratory training on a sitewide basis. There was less concern over worker exposure to PCBs through absorption, and many workers wore PCB-contaminated clothing. Some workers considered PCBs to be an effective remedy for dry skin.

The health physics staff provided exposure monitoring services, recommended training and protective measures for supervisors, maintained exposure and radiation measurement records, administered a bioassay program, investigated air samples and personnel exposures that were outside of specifications, studied Plant hazards and needed controls, and performed Plant environmental monitoring. However, the size of the Health Physics Section (i.e., two to six people during the first 37 years of operation) limited the amount and effectiveness of surveillance and monitoring of hazardous conditions and activities for the approximately 1,200 to 2,500 people in numerous and diverse work environments. While line supervision had always been responsible for implementing recommended controls and protective measures, supervisory oversight and worker implementation of PPE and related measures were inconsistent. Non-compliant PPE use by workers can in part be attributed to the pressures to maintain normal process operations, a lack of knowledge and understanding of the risks involved and why the protection was needed, and the physical discomfort and vision impairment associated with wearing PPE, such as respirators, in hot, dirty environments.

Safety Equipment

Most radiological work controls, including time limits on worker exposures to uranium, were based on the assumptions that the primary risks for uranium exposure were chemical, not radiological, and that uranium was soluble and would be eliminated by the body quickly through the kidneys. Thus, inhalation protection was encouraged, and bioassay urinalysis was employed from Plant startup to monitor intakes by workers who might be exposed to uranium or fluoride materials. However, the solubility assumption may not have been appropriate for some Plant areas, such as the metals plant and grinding and welding operations, where small particle sizes and relatively insoluble uranium compounds were present.

Limitations were established for uranium and fluoride levels and excretion rates, and personnel were removed from work areas with potential exposure until concentrations returned to acceptable levels. In 1968, in vivo radiation monitoring by lung counting was initiated, first by sending workers to Fernald or to Oak Ridge and later using a mobile counter periodically sent to PGDP from Oak Ridge. The intent of in vivo counting was to determine the activity of radionuclides trapped inside the body; for uranium, insoluble forms concentrate in the lungs and remain there for a relatively long time. Urinalysis would not detect intakes of insoluble uranium reliably and at sufficient sensitivity. However, lung-counting methods are not particularly sensitive and are suitable only for assessing relatively large intakes retrospectively. In vivo monitoring was performed on a sampling basis and, in the early years, typically relied on volunteers from work areas subject to uranium exposure. Film badges were used from the beginning of Plant operation to monitor personnel exposures to beta and gamma radiation, although prior to 1960, only selected workers were included in the film badge service based on their work activities.

In the mid- to late 1970s, health physics surveys of work practices, continuous airborne activity monitor analysis, and contamination surveys were routinely documented. Health physics personnel were aware of the presence of and hazards associated with neptunium-237, plutonium-239, and technetium-99, and actively encouraged proper respirator use, identifying instances of improper respirator use and recommending other changes to improve ventilation and minimize exposures. The sophistication and rigor of health physics surveys improved during the late 1970s; uranium, uranium daughter products, neptunium-237, plutonium-239, thorium-230, and technetium-99 were monitored, reported, and discussed with personnel. In the mid-1980s, the NRC and DOE were promulgating more stringent regulations for radiological control, and practices related to respiratory protection, contamination control, and personnel monitoring improved considerably.

2.6 Waste and Material Management

Over the years, solid wastes were disposed of in various locations including two landfills, four scrap yards, and three radioactive materials disposal sites. In addition, there were a number of smaller holding areas and special disposal sites. A burn pit in the northwest corner of the site was used for combustible waste until 1967. The landfill used for early construction rubble north of the Plant continued in operation as the Plant came on line, and another landfill outside the fence southwest of the Plant (known as the C-746 K Landfill) was created for steam plant ash disposal and evolved into a general landfill. Although there were some early specifications limiting placement of radioactive material in the landfills, there is no record of sampling to demonstrate compliance. Further, since records indicate that floor sweepings were disposed of in the landfills and spills of green salt and yellowcake were routine in several areas of the Plant, it is clear that radioactive materials were improperly sent to the sanitary landfills. In addition, waste materials (including radioactively contaminated materials) were disposed of in various areas outside the Plant boundary in what is now the Kentucky Wildlife Area. These areas are accessible to the public for recreational use. Unauthorized salvaging of scrap materials also occurred.

Some of the materials disposed of outside the Plant boundary have been identified as radioactive by subsequent site surveys or investigations carried out under the Federal Facility Agreement and by this investigation team. Scrap metals from C-340, the cascades, the feed plant, and the C-720 maintenance shop went to C-746F (classified burial), C-746E (contaminated material yard), C-746C (clean materials), or unclassified burial yards all within the security fence. From the beginning of Plant operations, efforts were made to control the spread of contamination and to separate contaminated materials from other waste. However, records and interviews indicated that compliance was inconsistent and monitoring minimal. Pyrophoric uranium metal shavings were disposed of in the C-749 burial ground from 1957 to 1977. In the 1950s, uranium powder scrap from C-340 was dumped into onsite pits. The primary radioactive waste disposal site was the original C-400 holding pond, which was